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Carbide Composite Coating On Steel By Laser Surface Engineering

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An iron based surface composite consisting of TiC and chromium carbides (Cr_7C_3, M_7C_3 where M=Cr, Fe) was produced *in-situ* on the surface of 1010 steel by laser treatment. The carbide composite surface layer hard carbide particles embedded in the steel matrix and can be applied to structures requiring resistance to wear and corrosion. AISI 1010 is plain carbon steel with a nominal carbon content of about 0.10%, has good formability and ductility but has relatively low hardness and is not suitable for applications requiring wear resistance. Hence, a laser-based technique was employed to achieve microstructural changes by surface alloying for enhancement of surface properties. The surface modification of materials using lasers has led to the development of coatings with rapidly solidified microstructure consisting of crystalline and amorphous and phases [1,2]. Such microstructures inherently have superior wear and corrosion properties than those obtained by conventional surface treatment. The steel substrate was sprayed with a powder mixture containing Cr, Ti, C and Fe. A 2 kW Hobart continuous wave Nd: YAG laser equipped with fiber optic beam delivery system was employed for laser treatment of the deposited samples The entire surface of the sample was laser treated with overlapping stripe of laser tracks. Extremely high cooling rates of 10^3-10^8 K/ sec associated with the laser processes greatly refine the microstructure [3]. Such cooling rates also produced metastable phases (martensite) in coating and a heat-affected region.

The various phases present, microstructure, microhardness and wear properties of the laser-modified specimen have been examined. Microstructural characterization of cross-sectioned samples revealed that laser coating was metallurgically bonded to the substrate and free from any structural defects. X-Ray diffraction of the samples treated at varying energy input indicated that TiC phase was prominently present and as the input energy increases, M_7C_3 (M= Cr, Fe) type carbide appears. Ti and Cr have strong carbide forming tendency and because of the surface treatment, *in situ* carbide formation was expected. Energy Dispersive Area X-Ray Analysis (EDAX) of the samples showed the presence of Ti, Cr, C and Fe in the coating indicating the presence of carbide particles in the coating. Microhardness was determined using a Knoop indenter across the coating at various loads. Indentation with high load at coating-substrate interface did not produce debonding, confirming good metallurgical bonding. Hardness values were almost constant within the coating and the values gradually decreased when indents were made across the coating through the heat-affected zone into the substrate material. Scratch with diamond stylus at different loads indicated substantial improvement in scratch resistance. Improvement in wear properties was expected. A block on disk wear test was carried out on coated as well as substrate samples. The weight loss was noted at periodic interval to determine wear rate, wear resistance of the laser processed coating was found to be far superior to the substrate.

Thus it can be concluded that due to the surface modification of the steel substrate by laser processing, the following have been achieved: *in-situ* carbide formation, refinement in

microstructure, substantial increase microhardness (nearly three fold) and scratch resistance, and tremendous improvement in wear resistance.

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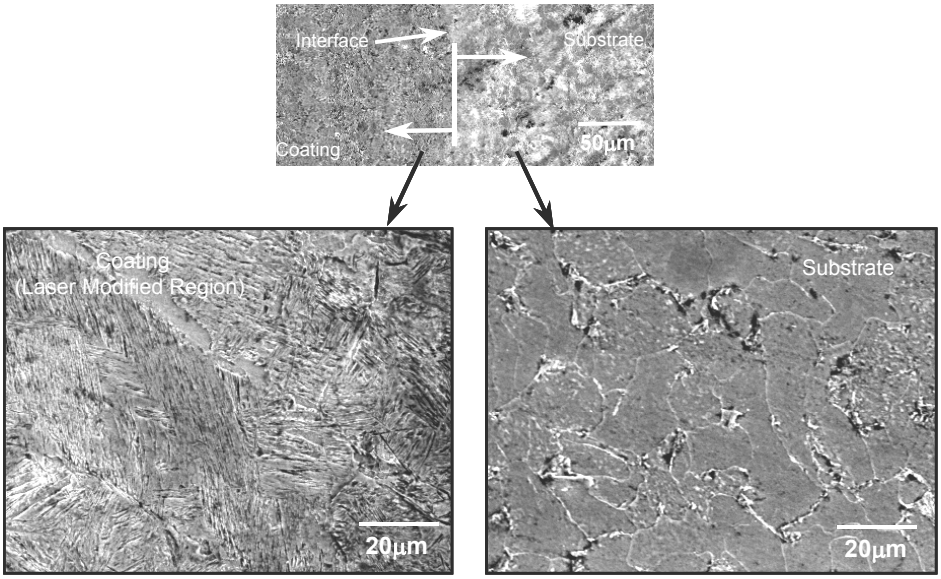

FIG 2: SEM micrograph of specimen etched with nital. Laser surface alloying caused extensive refinement in microstructure. The coating region is essentially martensitic. The coating region is essentially martensitic with various fine carbides (TiC, M_7C_3 where M = Cr, Fe).

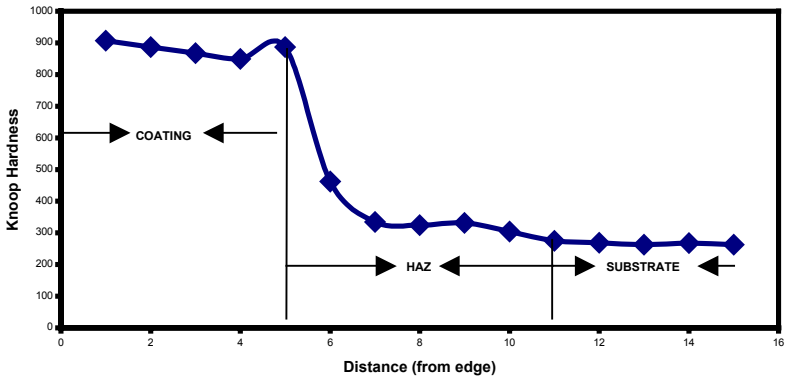

FIG 1: Microhardness variation with distance from the edge (each unit represents 50 microns) in the cross-section of the coating. The coating, HAZ and the substrate regions have been shown and it can be seen that the hardness decreasing as we move away from the coating.

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